Potato Breeding and Selection for Colorado

SUMMARY RESEARCH PROGRESS REPORT FOR 2009
AND RESEARCH PROPOSAL FOR 2010

Submitted to:

Colorado Potato Administrative Committee (Area II) - Research Committee

Title:

Potato Breeding and Selection for Colorado

Project Leaders:

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Collaborators:

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Samuel Y. C. Essah - Cultivar Specific Production Management
Sastry S. Jayanty - Cultivar Specific Postharvest Management and Physiology
Cecil Stushnoff and Henry J. Thompson - Nutritional Characteristics and Health Attributes
Jorge M. Vivanco - Molecular Studies - Nematode Resistance
Kent P. Sather and Richard W. Haslar - Potato Certification Service
Jennifer Bond - Marketing
Jairam Vanamala and Lavanya Reddivari - Bioactive Compounds for Health Laboratory
Marissa Bunning - Sensory Evaluations
Colorado Potato Growers

Other cooperating research/extension programs - several cooperators throughout the United States and Canada provide breeding material and opportunities to screen our germplasm under various growing conditions and disease pressures not available in Colorado.

Project Justification and Scope:

Many challenges and opportunities are confronting the Colorado potato industry. These challenges/opportunities include food safety, water quality/supply, current market constraints, new market development (processing, exporting, etc.), changing consumer expectations, and increasing costs with highly variable potato prices. To help meet these challenges, continued emphasis needs to be placed on developing new potato cultivars.

Potato cultivar development is a four-step process, encompassing first, the generation of segregating populations and evaluation for visual agronomic traits. Second, superior progenies are identified and

these selections undergo additional evaluation for economically important characteristics. Third, a profile of cultivar specific management criteria - production and postharvest - are developed, which a grower, shipper, processor, and/or marketer may fine tune for his/her operation. Finally, the new cultivar must be introduced to the intended market. These steps provide a base for a successful cultivar release. Without all components, fruition is difficult to attain.

The major objectives of the Colorado Potato Breeding and Selection Program are: (1) to develop new potato cultivars with increased yield, improved quality, improved nutritional and health characteristics, resistance to diseases and pests, and tolerance to environmental stresses; (2) to collaborate with growers, shippers, processors, and research/extension personnel to assess the production, adaptability, marketability, and other characteristics of advanced selections from the Colorado program; (3) to provide a basic seed source of selections to growers for seed increase and commercial testing; (4) to evaluate promising selections for possible export (interstate and international).

The primary emphasis is placed on the development of russet cultivars. The balance of the breeding effort is devoted to developing red, specialty, and chipping cultivars. This broad approach is important because it recognizes the diverse markets accessed by potato growers throughout Colorado.

Besides the major objectives outlined previously, specific breeding emphasis is being placed on identifying germplasm and developing cultivars that have: (1) early vine maturity and early tuber bulking; (2) immune to PVY; resistant to (3) late blight (foliar and tuber); (4) storage rots [dry rot (*Fusarium* and early blight) and bacterial soft rot]; (5) pink rot; (6) nematodes; (7) powdery scab; (8) corky ringspot, and (9) that have improved nutritional quality, health attributes, and other "consumer" characteristics such as improved red skin color retention and improved shelf life. ***An area of collaboration that we would like to develop in 2010 further is sensory evaluation for our advanced selections.***

Continued emphasis will be placed on developing sustainable and environmentally friendly cultivars by selecting for "low input" cultivars, primarily for reduced nitrogen and fungicide input, for improved postharvest and processing qualities such as lengthened dormancy and ability to process after cold storage. Cultivars with these characteristics will help assure that the potato industry in Colorado will remain productive and in a competitive position.

Methods:

Table 1 presents a description of the steps involved in developing new potato cultivars. It takes 14+ years to develop a new potato cultivar. Year 1 and 2 are the potato breeding phase of the development process. Parents are selected and crossed to produce true potato seed. Seedling tubers are then produced from the true seed in year 2. Subsequent years (3+) represent the selection phase of the development process. Each year represents another cycle of field selection. As each cycle is completed, fewer and fewer clones remain and the amount of seed per selection is increased. Clones remaining after eight cycles of field selection are released to growers for evaluations prior to official release as a named cultivar.

Facilities, Equipment, Personnel Support:

Facilities/Equipment. The Colorado Potato Breeding and Selection Program is based at the San Luis Valley Research Center. Current facilities and equipment needs are consistent with previous years' usage by this program.

Previously, the primary limiting facilities/equipment were associated with grading and postharvest evaluations. ***The goal still remains to try to acquire improved grading equipment for potato research projects to enhance our data collection process.***

Support Personnel. The financial support of a Research Associate/Research Scientist by the SLV potato industry for the Colorado Potato Breeding and Selection Program has been very valuable. We also rely on the current SLV Research Center staff to prepare fields for planting, assist in seed preparation, planting, and harvest activities. The collective support activities of Stan Price, Ron Price, Sharon Yust, and Deanna Brown are greatly appreciated.

Potential for Leverage of Outside Funding:

Ongoing support by the potato industry is fundamental to maintaining external funding received for the Potato Cultivar Development from NIFA (National Institute of Food and Agriculture - formerly CSREES) and other potential sources. Also, these funds are vital to maintaining collaborative relationships with other research projects supporting the overall potato research efforts in Colorado.

Project Timeline:

This project is ongoing. Potato cultivar development is a process encompassing a minimum time-period of 12 to 14+ years from hybridization to release of a new cultivar. Based on this time line, advanced selections from crosses made in 2010 will be available for grower evaluation in 2020. This illustrates the long term nature of potato breeding programs. It also underscores the importance of collaborative efforts in cultivar development, the impact of inadequate funding, and the significance that other research management decisions have on the characteristics that future cultivars will possess as we strive to meet the needs of the Colorado potato industry.

Significant Accomplishments for 2009

The following is a brief summary of research conducted in 2009.

The Colorado Potato Breeding and Selection Program intercrossed 109 parental clones in 2009 in two separate crossing blocks. The emphasis of the first crossing block was russet and specialty cultivar development. The second crossing block emphasized russet and specialty cultivar development and corky ringspot resistance. Seed from 399 combinations was obtained.

Approximately 55,960 seedling tubers representing 253 families were produced from 2007 and 2008 crosses for initial field selection in 2010. These seedlings represent crosses segregating primarily for russet, reds, specialty types, and resistance to late blight, PVY, corky ringspot, and nematodes. Second through fourth size seedling tubers will be distributed to Idaho (USDA-ARS), Minnesota, North Dakota, Oregon, Texas, Wisconsin, and Alberta, Canada (Agriculture Canada).

Colorado grew 81,644 first-year seedlings representing 481 families in 2009, with 810 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the USDA-ARS-Idaho, Agriculture Canada, Texas A&M University, and Oregon State University. Another 1,232 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 372

were saved for further increase and evaluation. Forty-eight advanced selections were saved and will be increased in 2010 pending further evaluation. Another 267 selections and cultivars were maintained for germplasm development, breeding, and other experimental purposes including seed increase/maintenance.

Field trials conducted in 2009 included: Preliminary Trial, Intermediate Yield Trial, Intermediate Specialty Yield Trial, Advanced Yield Trial, Southwestern Regional Russet Trial, Southwestern Regional Red Trial, Southwestern Specialty Trial, Western Regional Russet/Processing Trial, Western Regional Red Trial, Western Regional Specialty Trial, Western Regional Chipping Trial, and the San Luis Valley Chipping Trial. All trials are grown under "low input" conditions, primarily for reduced nitrogen and fungicide.

A total of 212 samples were evaluated for two or more of the following postharvest characteristics: blackspot susceptibility, storage weight loss, dormancy, enzymatic browning, specific gravity, french fry color, french fry texture, and chip color.

Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers in 2009, included 10 russets (AC96052-1RU, AC99375-1RU, CO94035-15RU, CO95172-3RU, CO97087-2RU, CO98067-7RU, CO98368-2RU, CO99053-3RU, CO99053-4RU, and CO99100-1RU), five reds (CO98012-5R, CO99076-6R, CO99256-2R, CO00277-2R, and CO00291-5R), seven chippers (CO95051-7W, CO96141-4W, CO97043-14W, CO97065-7W, CO00188-4W, CO00197-3W, and CO00270-7W), and 17 specialties (AC97521-1R/Y, AC99329-7PW/Y, AC99330-1P/Y, ATC00293 -1W/Y, CO97222-1R/R, CO97226-2R/R, CO97227-2P/PW, CO97232-1R/Y, CO97232-2R/Y, CO97233-3R/Y, CO99045-1W/Y, CO00379-2R/Y, CO00405-1RF, CO00412-5W/Y, CO00415-1RF, CO01399-10P/Y, and VC1009-1W/Y).

Table 2 compares the more advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Mesa Russet (CO94035-15RU) was named in 2009. Mesa Russet is a high yielding, dual-purpose russet. It has a medium maturity and a high percentage of US #1 tubers. It is resistant to second growth, blackspot bruise, shatter bruise, powdery scab (tuber and root galling) and verticillium wilt. Mesa Russet has also shown potential to fry after storage.

A chipping selection, CO95051-7W, has been recommended for release by the USPB Fast Track program. This program facilitates advanced chipping selections to undergo commercial evaluation after being evaluated in the USPB/SFA trial program.

The following collaborative studies were conducted in 2009. These programs have their own funding for these projects and funding is not requested in our budget to support these efforts.

- Several advanced selections were evaluated for disease symptom expression screening trials in Colorado. These trials were conducted in cooperation with Rob Davidson, Andrew Houser, Kent Sather, and Rick Haslar. Included were bacterial ring rot (8 entries), potato leafroll virus (11 entries), PVY (13 entries), and powdery scab (26 entries) in Colorado.

- Several advanced selections were distributed to state/USDA-ARS collaborators in Idaho, Michigan, Oregon, Texas, Washington, and Wisconsin for additional disease evaluations. These selections were screened for one or more of the following diseases: late blight, early blight, scab (common and

powdery), PVY, *Verticillim* wilt, and zebra chip. In addition, selections were provided to the National Trials for late blight and scab (powdery and common) screening.

- Germplasm is continually being acquired with late blight resistance, virus resistance (PXY, PVY, corky ringspot and leafroll), and nematode resistance from various sources. Primary sources of new germplasm are the USDA-ARS in Aberdeen, Idaho; Prosser, Washington; Madison, Wisconsin; and Oregon State University in addition to resistant selections identified in our program. These materials are being selectively introgressed into the breeding program.

- Advanced selections were evaluated in cultural management trials in collaboration with Samuel Essah. Twenty-two advanced selections were included in these trials.

- Tubers of selected clones/cultivars were provided to Jairam Vanamala and Lavanya Reddivari to support grant research projects conducted by the Bioactive Compounds for Health Laboratory in the Department of Food Science and Human Nutrition at CSU.

Objectives for 2010: (Note - some of objectives listed are funded through other sources and are presented here for information only).

1. The potato breeding and selection program will be continued. This aspect of the program is primarily oriented to developing new potato cultivars. ***Note:*** With the current virus situation with Russet Norkotah, continued emphasis will be placed on developing cultivars that have early vine maturity and early tuber bulking.

   Advanced clones will be tested in yield trials, Southwestern Regional Trials, Western Regional Trials, out-of-state trials, and by growers.

2. Adjunct breeding initiatives have been started over the last few years and will continue. These initiatives are focused on increasing disease resistance and the nutritional and health attributes of potatoes in collaboration with other CSU faculty.

   a. Disease resistance breeding has focused on introgressing parental material with identified resistance to late blight, immunity to PVY, tuber resistance to dry rot (*Fusarium* and early blight), bacterial soft rot. Additional emphasis is being placed on identifying and incorporating germplasm demonstrating resistance/immunity to pink rot, powdery scab, corky ringspot, and nematodes.

   b. Parental material with improved nutritional and health characteristics will be incorporated in the breeding and selection program. We currently are increasing our emphasis on taste/flavor and will be identifying novel material that may be useful to incorporate into our breeding program. Concurrently new efforts will be directed to sensory evaluations of advanced selections both via taste panels and alternative screening techniques. This work is in collaboration with Sastry Jayanty.

   c. Develop an ongoing collaborative effort with Marissa Bunning, Department of Food Science and Human Nutrition at CSU, to evaluate advanced selections and cultivars for sensory characteristics.

3. *In vitro* culture studies with breast and colon cancer cells will be used to screen several potato clones for inhibitory effects. This is a collaborative study with Cecil Stushnoff and Henry Thompson.

4. Clones in the 7th cycle of field selection will be evaluated in cultural management trials and for postharvest disease reaction. Disease evaluations will be conducted primarily on bacterial soft rot and dry rot (Fusarium and early blight). Screening for corky ringspot resistance will be initiate this year. These studies will be conducted in cooperation with Rob Davidson, Samuel Essah, and Russ Ingham.

5. Collaborative efforts will continue to focus on an "accelerated" breeding approach for high priority characteristics. This would employ greenhouse and field evaluations, where appropriate, to characterize breeding material earlier in the selection program. Primary focus will include PVY, powdery scab, corky ringspot, and pink rot.

6. Continue the use of on-farm trials to: (1) assist in the development of management guidelines; (2) detect unforeseen problems; (3) determine predictability of performance; and (4) screen for disease reaction [foliar and tuber (pink rot and powdery scab)]. This will be a collaborative effort with Rob Davidson and Samuel Essah. Please refer to the research reports of Rob Davidson and Samuel Essah for 2009 results.

7. Evaluate preliminary, intermediate, and advanced selections from the breeding project, Southwestern Regional Trials, and Western Regional Trials for: blackspot susceptibility, storage weight loss, dormancy, enzymatic browning, specific gravity, chip color, french fry color, and french fry texture.

Budget Request for 2010 (same as 2009 request):

Request	$62,500	
Postdoc	35,100	Salary plus fringe benefits
Temporary Labor	15,750	Hourly support personnel
Supplies	6,500	Miscellaneous greenhouse and field supplies
Travel	700	Travel within Colorado
Equipment & Maintenance	2,100	Greenhouse and assistance to SLVRC
Chemicals	2,350	Primarily greenhouse chemicals

Table 1. Generalized potato breeding and selection scheme used at the SLV Research Center.

Year	Comments
1	Select parents for crossing and true seed production in the greenhouse.
2	Produce seedling tubers from true seed in the greenhouse.
3	70,000-80,000 seedling tubers planted in the field as single hills. Several thousand tubers are obtained from other breeding programs. Initial selection of this material takes place at harvest. First cycle of field selection.
4	Twelve-hills of each single-hill selection are planted. Second cycle of field selection.
5	Preliminary Selections 1 (P1). Third cycle of field selection (48 plant tuber-unit seed increase). Initial evaluations for chipping qualities (chip color after various storage regimes and specific gravity) are conducted this year and subsequently.
6	Preliminary Selections 2 (P2). Fourth cycle of field selection (96 plant tuber-unit seed increase). Initial evaluations to characterize selections for blackspot bruise potential, storage weight loss, dormancy, and enzymatic browning. Initial evaluations for french fry potential (french fry color and specific gravity) are conducted this year and subsequently. Evaluations for chipping qualities are continued.
7	Intermediate Selections. Fifth cycle of field selection. Initial data collected on yield, grade, and growth characteristics. Plant a 144 plant tuber-unit seed increase and a 2 rep x 25 plants intermediate yield trial (IYT).
8-9, 14+	Advanced Selections: Includes selections that have advanced from the IYT. Additionally selections are included that have graduated from the Southwest Regional and Western Regional Trials. The advanced yield trials for reds, specialty types, and chippers are planted with entries in the Western Regional Red, Specialty and Chip Trials. Selections are in the 6th-7th and 12+ cycles of field selection. All advanced yield trials (AYT) have 4 reps x 25 plants. Sixth- and seventh- year field selections respectively have a 400/1,600 plant tuber-unit seed increase. Selections in the sixth cycle of selection are indexed for viruses and cleanup/micropropagation is initiated. Testing for ring rot and PLRV reaction is also initiated at this stage and continues as needed. Selections in the 7th cycle of field selection are entered into cultural management trials and postharvest disease reaction (dry rot and soft rot) evaluations.
10	All 8th year selections have a 1/2 acre tuber-unit seed increase planted. These selections are entered in the Southwestern Regional Trials (4 locations - CO, TX, CA). Cultural management trials and postharvest disease reaction evaluations continue as needed.
11-13	All 9th year or older selections generally have a 1 acre or greater seed increase. These selections are entered in the Western Regional Trials (4 trials): main (russets and long whites), red, specialty , and chip. The Western Coordinating Committee (WCC-27) directs these trials at 10+ locations in the Western United States each year. Cultural management trials and postharvest disease reaction evaluations continue as needed.
11+	Grower/industry evaluations. The Colorado Potato Breeding and Selection Project relies on the cooperation of several growers, shippers, and processors to evaluate advanced selections for adaptability and marketability.
14+	Release as a named cultivar.

Table 2. Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Clone	Usage[1]	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity[2]	Specific Gravity	% External Defects[3]	% Hollow Heart[4]
Russets								
CO95172-3RU	FM	9	500	79	3.2	1.089	1.0	0.5
AC96052-1RU	Dual	8	441	86	3.2	1.090	0.8	0.2
CO97087-2RU	Dual	7	433	85	3.0	1.096	1.7	0.3
CO98067-7RU	Dual	6	476	84	2.5	1.078	0.8	0.0
CO98368-2RU	FM	6	405	70	2.3	1.083	0.9	0.0
AC99375-1RU	Dual	5	512	82	3.1	1.100	1.7	0.0
CO99053-3RU	Dual	5	516	90	3.5	1.089	2.5	0.7
CO99053-4RU	Dual	5	362	84	2.1	1.085	1.4	0.0
CO99100-1RU	Dual	5	373	83	1.4	1.084	4.6	0.1
Canela Russet	FM	11	386	90	3.1	1.096	1.3	0.1
Centennial Russet	FM	35	294	77	3.0	1.080	0.8	0.3
Mesa Russet	Dual	10	419	86	2.9	1.082	1.8	2.5
Rio Grande Russet	FM	22	533	80	3.0	1.087	2.8	0.4
Russet Norkotah	FM	78	385	84	1.8	1.079	2.2	0.4
Russet Nugget	Dual	64	441	81	3.8	1.093	1.5	0.2
Reds								
CO98012-5R	FM	6	466	77	3.0	1.080	0.7	0.3
CO99076-6R	FM	5	402	76	1.5	1.086	2.2	0.0
CO99256-2R	FM	5	512	65	2.9	1.088	0.4	0.1
CO00277-2R	FM	4	419	76	1.6	1.080	0.9	0.5
CO00291-5R	FM	4	384	79	3.4	1.083	0.5	0.0
Colorado Rose	FM	14	517	85	2.7	1.082	2.7	0.3
Rio Colorado	FM	11	405	56	1.7	1.087	0.9	0.0
Sangre-S10	FM	24	542	88	3.3	1.077	1.8	1.7

Table 2 continued on next page.

Table 2 (cont'd). Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Clone	Usage[1]	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity[2]	Specific Gravity	% External Defects[3]	% Hollow Heart[4]
Specialties								
AC97521-1R/Y	Spec	7	578	78	2.9	1.090	0.8	1.2
CO97226-2R/R	Spec	7	364	34	2.3	1.080	0.2	0.0
CO97232-1R/Y	Spec	7	420	67	2.0	1.081	0.8	0.0
CO97232-2R/Y	Spec	7	440	84	2.6	1.071	0.8	1.0
CO97233-3R/Y	Spec	7	477	73	3.3	1.082	4.0	2.3
CO97222-1R/R	Spec	6	394	55	2.4	1.076	1.5	0.0
CO97227-2P/PW	Spec	6	483	24	2.8	1.087	1.0	0.0
AC99329-7PW/Y	Spec	5	537	76	3.0	1.091	1.6	0.4
AC99330-1P/Y	Spec	5	503	53	2.8	1.082	0.0	0.2
CO99045-1W/Y	Spec	5	556	78	3.2	1.088	2.9	0.0
ATC00293-1W/Y	Spec	4	577	84	3.0	1.082	4.5	3.1
CO00405-1RF	Spec	4	262		1.3	1.080	2.8	0.0
CO00412-5W/Y	Spec	4	489	72	2.8	1.088	2.7	0.9
CO00415-1RF	Spec	4	357		1.3	1.075	4.3	0.0
Mountain Rose	Spec	8	383	68	2.2	1.081	1.1	0.0
Purple Majesty	Spec	12	496	58	2.1	1.085	0.6	1.3
Yukon Gold	Spec	22	413	89	1.8	1.086	1.6	0.6
Chippers								
CO95051-7W	Chip	8	413	86	3.3	1.100	1.0	0.4
CO96141-4W	Chip	8	416	87	2.6	1.087	1.1	0.0
CO97043-14W	Chip	7	431	81	2.9	1.089	1.4	0.3
CO97065-7W	Chip	7	424	83	2.6	1.099	0.9	0.2

Table 2 continued on next page.

Table 2 (cont'd). Summary comparison of advanced selections and named cultivars for yield, grade, maturity, specific gravity, and grade defects.

Clone	Usage[1]	# Trials	Total Yield (Cwt/A)	% US #1	Vine Maturity[2]	Specific Gravity	% External Defects[3]	% Hollow Heart[4]
CO00188-4W	Chip	4	446	74	2.6	1.091	1.1	0.1
CO00197-3W	Chip	4	481	72	2.3	1.086	0.8	1.0
CO00270-7W	Chip	4	429	83	2.6	1.088	1.1	0.0
Atlantic	Chip	36	460	86	3.2	1.098	2.6	5.0
Chipeta	Chip	34	541	84	3.3	1.090	5.1	0.5

[1] FM=fresh market; Dual= fresh market and processing potential; SPEC=specialty.

[2] Vine maturity: 1=very early; 2=early; 3=medium; 4=late; 5=very late.

[3] Includes defects such as second growth, growth crack, misshapen, and green.

[4] Based on tubers greater than 10 ounces.